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EFFECT OF INDUSTRIAL WASTE DUMPS ON THE QUALITY OF RIVER WATER

WPŁYW SKŁADOWISK ODPADÓW PRZEMYSŁOWYCH NA JAKOŚĆ WÓD RZECZNYCH

Abstract: Landfills are an important source of industrial pollution of surface and groundwater area in the vicinity of waste heaps. Hydrosphere pollution is mainly a consequence of the formation of leachate with high concentrations of toxic substances. In addition to substances considered as a typical toxic materials such as cadmium and lead, leaching water may contain high concentrations of other ions. These include the sulfates, chlorides and sodium. The paper presents the results of landfill leachate of colliery waste tip "Panewniki" located in the catchment of river Jamna (Mikolow). Post coal mine waters are characterized by very high electrical conductivity, which ranges from 7.5 to 8.3 mS · cm^{-1} in the case of the first effluent and from 7.9 to 10.6 mS · cm^{-1} in the case of the second effluent, respectively. Such high values of conductivity are caused by leaching of waste deposited in a heap. As a result of leaching process the increase of the concentration of individual ions also occurs. These can include sodium and chloride. The maximum sodium concentration may exceed the 2500 mg · dm^{-3} and 560 mg · dm^{-3} chlorides.

Inflow of effluents into the river Jamna affects significant changes in water quality. The statistically significant differences in the concentrations of sodium and chloride in the waters above and below Jamny flow of leachate were demonstrated.

Keywords: leachate, landfill, water pollution, river, water quality

The chemical composition of river waters is dependent on many factors. Amongst most important ones are: type of bedrock and climate [1]. It can undergo spatiotemporal changes. The concentration of ions has an impact on discharge [2].

In last decades inflow of pollution both from point, linear and surface sources increased considerably [3, 4]. Especially landfills as industrial waste tips in some areas are important sources of water pollution.

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Hydrosphere pollution in these type of sites is mainly a result of creation of leachate with high concentration of toxic substances as lead cadmium. There are high contents of other ions as sulphures, chlorides and sodium. This study focus on the influence of leachate of colliery waste tip "Panewniki" on quality of water Jamna in Mikolow near Katowice (Silesian Upland) (Fig. 1).

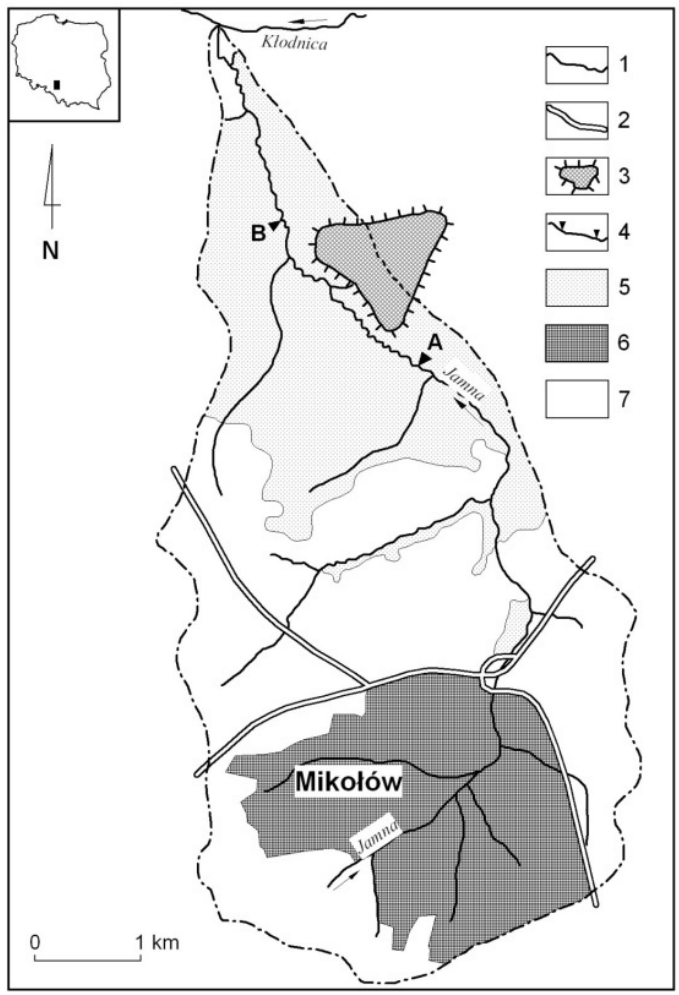

Fig. 1. Localization of dumping "Panewniki" [9]: 1 – Water courses, 2 – Roads, 3 – Dumping, 4 – Points of water sampling, 5 – Forest, 6 – Build- up area, 7 – Fields

Material and methods

The hydrogeographical mapping aiming at estimation of water relations of waste tip was carried out according to methodological assumptions by [5]. The measurement of

pH, temperature, conductivity as well were performed in the field by the device Multi – Line P – 4. The determination of selected ions was done according to methods of hydrochemical studies [6, 7].

The measurements of flow intensity were performed by RBC flume for water discharge measurement by Eijkelkamp company. To determine how leachate waters affect the quality of Jamna river waters two study plots were located in river. The study site "3" was placed above outflow and study site "4" below inflow of leachate waters. Also in sites of leachate outflows two study sites "1" and "2" were established (Fig. 2).

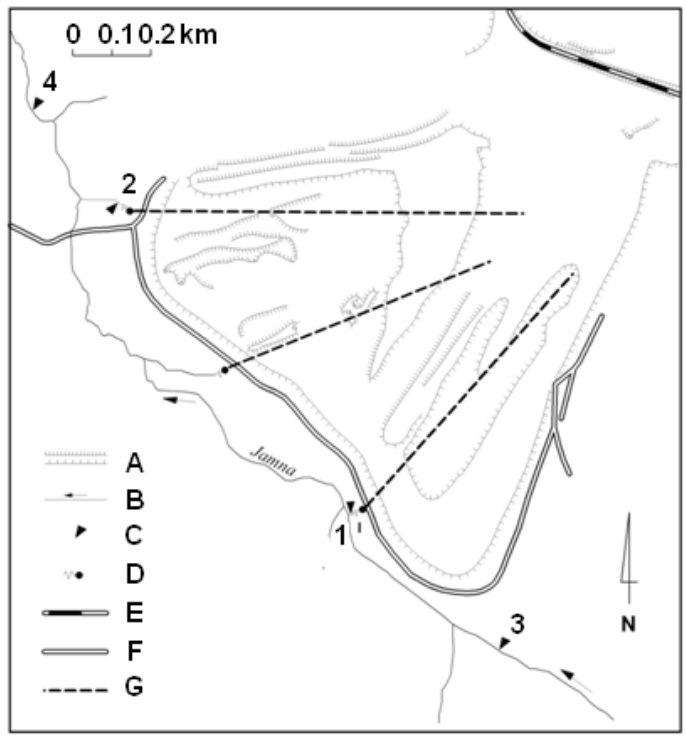

Fig. 2. Localization of inflow of leachate waters of the landfill "Panewniki": A – margins of the waste heap, B – water courses, C – points of water sampling: 1–4, D – outflows of leachate waters, E – railways, F – roads, G – buried old drainage system of canals

For the purpose of statistical analyses data gathered in the years 2002–2008 (minimal number of observations n = 12) were employed. Statistical analyses of obtained data was carried out using free statistical software R (R development Core Team 2011). In graphs, the following description of study sites was used: 1, 2 – leachates of Panewniki landfill and 3, 4 – study sites located in Jamna river.

For the purpose of the study Jamna river which is situated in Katowice Uplandwas was chosen. Jamna is a left tributary of Klodnica river and its length is estimated to be about 12 km. In the lower part of catchment, the coal mine "Panewniki" landfill of

wastes is located (Fig. 1). It is an aboveground waste heap. The object is characterized by concentrated outflows of leachate waters. These kind of outflows are formed most frequently where deposition of wastes leads to fulfilling of river valleys [8].

In this case there is a different situation. The studied waste heap was created in the site of former sandpit, which after cessation of exploitation was filled by mine wastes (Fig. 3). The deposition of wastes did not finish when landfill was leveled. The wastes were deposited further and leveled-aboveground landfill was formed 13 m high. The

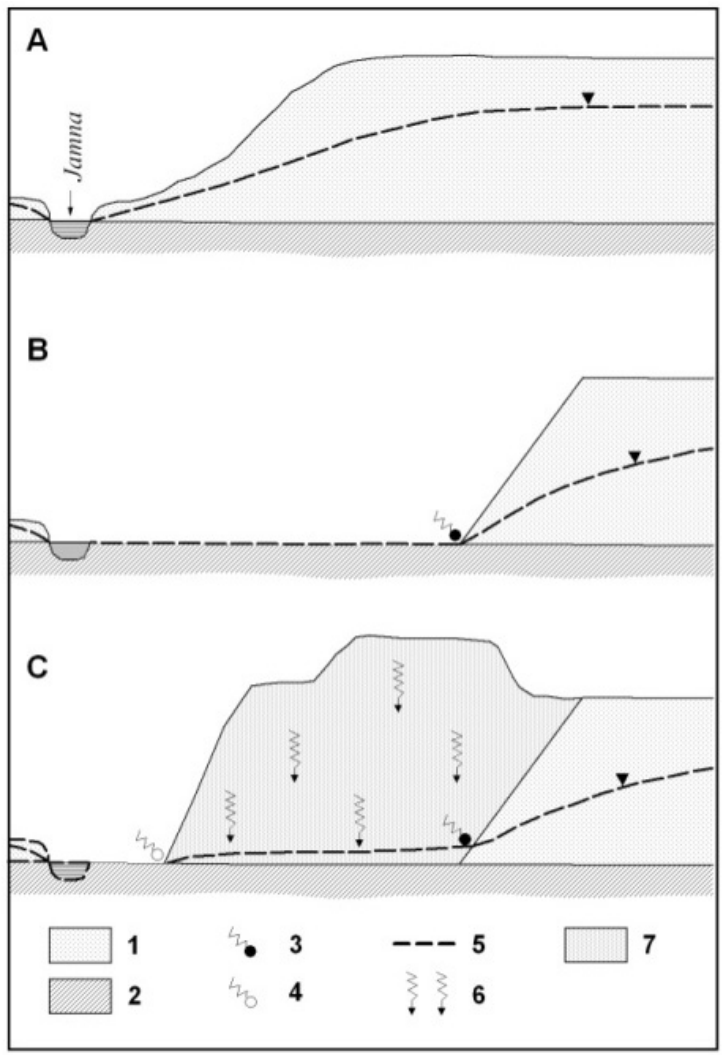

Fig. 3. Changes in relief and water relations within waste tip "Panewniki" [9]: A – State in 1950 before sand exploitation, B – state in 1970 during sand exploitation, C – present state in 2010; 1 – sands with gravel, 2 – boulder clay, 3 – outflows of underground waters, 4 – leachate, 5 – water level of underground waters, 7 – barren rocks

surface of the waste tip amounted to ca 118 ha. The introduction of effluents is at site of intersection between the block and topographic surface of the bottom of former drainage canals in sandpits (Fig. 3). In the landfill there are two permanent leachate outflows. In this waste tip apart from infiltration waters the resource of leachate are underground waters flowing from the margin of depression funnel. Perhaps underground waters are bigger part in the balance of leachate waters than infiltration waters.

Results and discussion

The leachate waters of the studied landfill are characterized by very high electric conductivity which varies from 7.2 to 8.3 mS · cm^{-1} in the case of "1" and 7.9 to 10.6 mS · cm^{-1} respectively in study site "2" (Fig. 4). So high values of conductivity are caused by leaching of deposited wastes on the landfill. There are statistically differences in conductivity of leachate waters both in terms of space and time.

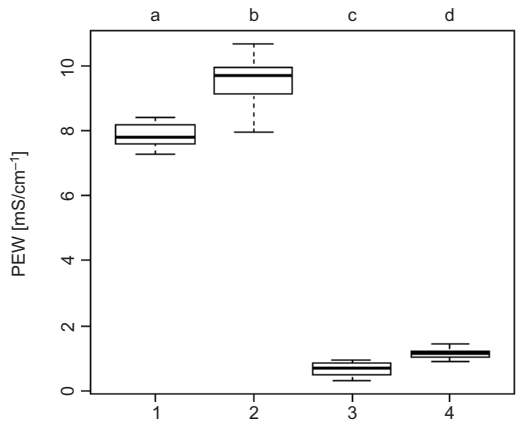

Fig. 4. Comparison of PEW between particular leachate waters of the landfill "Panewniki". The small different letters above mean that mean values differ significantly at $p < 0.05$

Coefficient of variation (Cv) for site "1" amounts to 26 % and for "2" – 32 %. For a comparison in natural springs value of this coefficient does not extend a few percent [9]. Also in waters of Jamna river above the landfill value of this coefficient was low and amounted to 6 %. Inflow of leachate waters to river Jamna influence their conductivity.

Conductivity increased significantly in waters of Jamna below inflow of leachate (Fig. 4). The value of coefficient of variation increased to 17 %.

As a result of leaching, the concentration of particular ions increased as well. These are sulphates, chlorides and sodium. Amongst wastes of coal mine industry are sulphates [8, 10, 11]. Their source are pirytes FeS_2, because anion S^{2-} in moist environment in anaerobic conditions is being oxidized to SO_4^{2-} [12].

The concentration of this ion in leachates varied between 4160 to 5730 mg · dm^{-3} (Fig. 5). In case of sulphates there were no significant differences in particular

leachates. Such differences were observed in river Jamna (Fig. 5). Inflow of leachate caused the increase of contents of sulphates in waters of Jamna from 5 % in study site "3" to 15 % in "4".

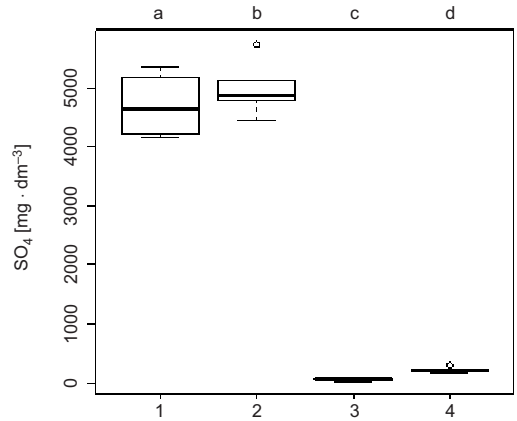

Fig. 5. Comparison of sulphates between particular leachate waters of the landfill "Panewniki". The small different letters above mean that mean values differ significantly at $p < 0.05$

In the case of chlorides and sodium the similar influence on quality of waters in Jamna was observed. Below inflow of leachate there was statistically higher concentration of studied ions (Fig. 6, 7). In case of sodium the value of variation coefficient increased from 3 % in study site 3 to 11.4 % in study site 4. There were no statistically significant differences in potassium concentration above and below leachate waters inflow (Fig. 8). It may be explained by relatively low concentration of potassium in leachate waters which is 85 mg/dm^{-3} on average. However, below the inflow greater variation of potassium concentrations (Cv = 9.4 %) than above the inflow (Cv = 7.5) can be noticed.

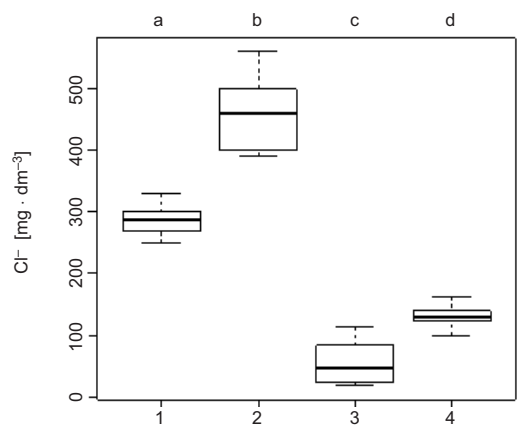

Fig. 6. Comparison of chlorides between particular leachate waters of the landfill "Panewniki". The small different letters above mean that mean values differ significantly at $p < 0.05$

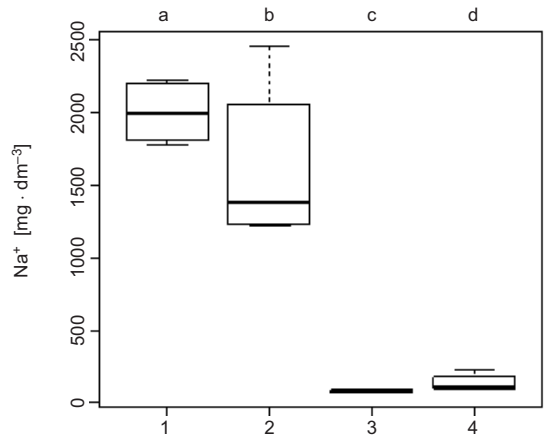

Fig. 7. Comparison of sodium between particular leachate waters of the landfill "Panewniki". The small different letters above mean that mean values differ significantly at $p < 0.05$

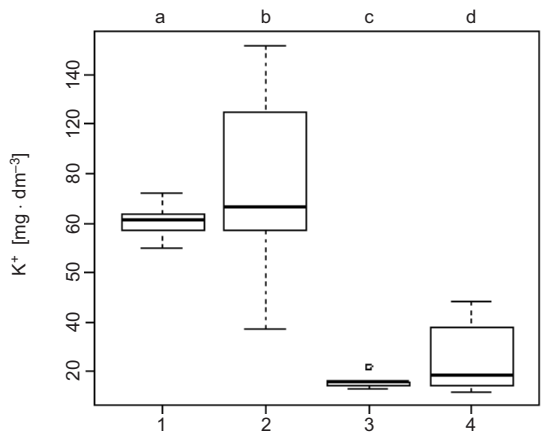

Fig. 8. Comparison of potassium between particular leachate waters of the landfill "Panewniki". The small different letters above mean that mean values differ significantly at $p < 0.05$

Conclusions

The obtained results let to draw the following conclusions:

– leachate waters of colliery waste tips are characterized by high conductivity and high contents of SO_4^{2-}, Cl^-, Na^+ and K^+;

– inflow of leachate to Jamna river does not lead to the increase of K^+ concentration in its waters;

– inflow of leachate to river Jamna lead to increase of conductivity and high contents of SO_4^{2-}, Cl^- and Na^+ in its waters;

– inflow of leachate lead to higher variation of high concentrations of SO_4^{2-}, Na^+ and K^+ in waters of river Jamna;

– the landfills of coal mine wastes can be considered as surface and permanent sources of pollution of surface waters.

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Abstrakt: W artykule przedstawiono wpływ składowiska odpadów przemysłowych na jakość wód rzeki Jamny. Wykazano, że wody odciekowe charakteryzuje bardzo dużą konduktywnością elektryczną oraz wysokim stężeniem jonów SO_4^{2-}, Cl^-, Na^+ oraz K^+. Jest to następstwo ługowania zdeponowanych na składowisku odpadów. Dopływ odcieków do rzeki Jamny powoduje wzrost konduktywności elektrycznej jej wód oraz stężenia jonów SO_4^{2-}, Cl^- oraz Na^+. Tym samym składowiska odpadów przemysłowych stanowią trwałe ognisko zanieczyszczenia wód powierzchniowych.

Słowa kluczowe: zanieczyszczenie wód, wody odciekowe, składowiska odpadów, jakość wód rzecznych